Pacific Coast Oil Spill

PRELIMINARY EXPERIMENTAL DESIGN

for the
ASSESSMENT OF
SHORELINE CLEANUP OPTIONS

ENVIRONMENT CANADA
Technology Development

January 1991

PACIFIC COAST OIL SPILL

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Results of a Workshop
December 4, 1990
Seattle, Washington

ENVIRONMENT CANADA
Technology Development Branch
Edmonton, Alberta

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FORWARD

This report is the fourth in a set of discussion and planning documents related to a federal government initiative for field research to improve marine coastal spill response capabilities in Canada. *The report is supported by a scoping document, literature assessment, and concept document (see references).*

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SUMMARY

This report summarizes the results of a meeting of oilspill experts that was held to discuss the initial design framework and major components for a field evaluation of shoreline cleanup options for Pacific coast coarse sediment beaches.

The overall objective of the experiment, as defined at the meeting, is **to assess environmental impacts and effectiveness of promising cleanup options for coarse or mixed-sediment beaches.**

The experimental strategy is to conduct small-scale oilspills in the field. Several embayments or sections of shoreline would be oiled and various cleanup techniques applied to each. Comparison of biological effect data and oil budget estimates would be used to determine the oil fate and effects under different treatments (cleanup techniques) and the relative effectiveness of those treatments.

Such an experiment would address several critical issues with respect to shoreline cleanup. These issues include the ecological impact of various countermeasures themselves; the effectiveness of various countermeasures options compared to natural self-cleaning processes; the problem of subsurface oil and how to treat it; and the role of bioremediation in future spill response.

The experiment would focus on low to medium wave energy coarse sediment or relatively porous mixed-sediment beaches. These beaches are biologically productive. They can trap large quantities of oil within subsurface sediments, which may re-oil adjacent, clean areas, or serve as a contaminant source to intertidal and subtidal biota. Oil removal by natural processes can be slow, and oil in subsurface sediments also presents problems in terms of enhanced (technological) cleanup. It is suggested that testing be conducted with crude and bunker oils as these are common commodities in most marine areas of Canada (crude in terms of volumes; bunkers in terms of frequency of transport).

Five cleanup techniques are recommended for testing. These are in order of priority; (1) cold-water, low-pressure washing, (2) hot-water, high-pressure washing, (3) tilling, (4) bioremediation and (5) washing with cleaning agents. These countermeasure techniques are reasonably representative of a wide-range of cleanup techniques that are available in a typical spill response.

The final selection of experiments (combinations of techniques and oil types) would depend on a number of practical constraints such as the number and location of suitable sites, and the oil volumes agreed to by the applicant, regulatory agencies, and local representatives.

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BACKGROUND

Early in 1989, Environment Canada initiated a study to assess oilspill countermeasures techniques and technologies which were potentially applicable to Pacific west coast oilspill scenarios, with the purpose of identifying knowledge and technological gaps which required field oriented research and evaluation. A scoping document and preliminary plan (Dickins 1990) outlined the findings and recommended possible field programs to address the deficiencies.

A decision was made to focus on shoreline cleanup as the most pressing area of concern. The 'Nestucca' and 'Exxon Valdez' experiences strongly emphasized the lack of knowledge and technological inadequacies with respect to shoreline cleanup.

A subsequent literature assessment (Goden 1990) clearly showed a lack of quantitative information on relative effects and effectiveness of different shoreline cleanup techniques for coarse sediment shorelines. Such information is essential to making informed decisions about the best approach to cleaning up a spill in different circumstances.

Shortly thereafter, a document called the 'Pacific Coast Oil Spill Concept' (Dickins 1990) was prepared. It described more concisely, the need, rationale, conceptual design and concerns about a experimental oilspill study to address issues related to shoreline cleanup.

On 4 December 1990, a meeting was held to discuss and identify more specifically, the individual experimental components, the hypothesis and techniques which might be tested as part of a west coast experimental oilspill program.

In attendance were experts representing a broad range of disciplines and with considerable experience in oilspill response. All participants were involved substantially in either the 'Nestucca' or 'Exxon Valdez' spills. Participants (see Appendix A) included:

Bill Stillings, Cook Inlet Spill Response Organization - shoreline cleanup operations and techniques, response planning.
Dave Kennedy, NOAA HAZMAT - scientific support coordinator to On-Scene Commander, fate and persistence studies.

David Little, Woodward-Clyde Consultants - experimental oilspills, fate and persistence studies, oiled-beach sediment sampling.
David Dickins, D.F. Dickins Associates - oilspill sensitivity analyses, experimental oilspills, oil and ice interaction.
Ed Owens, Woodward-Clyde Consultants - shoreline monitoring and cleanup, fate and persistence studies, sensitivity analyses.
Gary Sergy, Environment Canada - experimental oilspills, fate and persistence studies, nearshore habitat impact assessment.
John Harper, Harper Environmental Services - shoreline sensitivity and cleanup, fate and persistence studies.
Mike Flynn, Fisheries and Oceans Canada - fisheries habitat protection.

The meeting focused discussions of shoreline cleanup technology, its present deficiencies and impacts. Participants developed a list of "issues" that incorporated many of these deficiencies and then outlined experiments that could answer questions surrounding the issues. Implications in having to select a technique based on trade-offs between effectiveness in removing oil and ecological impacts were discussed.

There was consensus of participants at the meeting that scientific studies of accidental spills to date, including recent west coast spills such as the 'Nestucca' and 'Exxon Valdez', have not provided the necessary data to fully resolve the deficiencies in our understanding of shoreline cleanup processes. Likewise it was concluded that a controlled experimental spill represents the best means of addressing these deficiencies and the questioned posed.

The remainder of this document describes the output from the meeting in the form of a preliminary experimental design.

EXPERIMENTAL RATIONALE

OBJECTIVE

The primary objective of the proposed experiment is,

to assess environmental impact and effectiveness of cleanup options for coarse or mixed-sediment beaches.

The objective recognizes that coarse sediment beaches can represent a significant problem at spills; that cleanup options must be evaluated in terms of their short and long-term environmental effects as well as effectiveness; that considerable debate exists about the selection and use of various cleanup options and the associated trade-offs.

STRATEGY

The experiment proposes the deliberate spillage of small volumes of oil in a carefully controlled manner, onto the intertidal zone of separate beach segments or small embayments. Each is then treated with one of the cleanup techniques being tested. At least one oiled beach must be left untreated to determine natural self-cleaning processes. Oil and biota in and on intertidal and nearshore sediments are then monitored as an index of change. This provides a measure or indication of biological effects, recovery, and uptake, oil movement, persistence, and removal effectiveness. Control (non-oiled) sites are also monitored to document natural variations of species diversity and density that may be unrelated to the oil effects. In addition, a non-oiled bay may be treated to ascertain the impact of the cleanup technique by itself (some are highly disruptive).

The rationale for the experimental oilspill option and field experimentation is elaborated in Dickins 1990. The approach follows that used in several other studies, most notably, the Baffin Island Oil Spill (BIOS) Project. The results from the (BIOS) project are routinely used in the evaluation of impacts during response planning activities for northern shorelines. The results from that project provided an objective assessment of tradeoffs between countermeasure treatment and non-treatment in terms of oil fate and effects for that particular type of shoreline and oil spill scenario. The proposed Pacific Coast Oil Spill experiments would provide a similar much need assessment for a common and problematic west coast scenario.

ISSUES

The following were identified as the major issues that routinely pose problems in shoreline cleanup operations and issues where there is little information on which to base rational decisions about tradeoffs.

- Countermeasure Impact - the degree of ecological impact to either biota, habitats or resources caused by various cleanup techniques.
  - what is the tradeoff between oil removal and the ecological or resource impact of the countermeasures?
  - what is the comparative impact of different countermeasures on intertidal biota? which has the most impact? which has the least?
  - do countermeasures substantially reduce oil impacts on nearshore ecology?
  - how much do countermeasures accelerate (or delay) natural recovery?

- Countermeasure Effectiveness - the amount of oil removed by cleanup techniques in comparison to the amount of oil removed by natural processes (i.e., the reduction in oil concentration due to a particular countermeasure technique).
  - what is the most effective technique for removing surface oil? subsurface oil?
  - can the tradeoff between effort and degree of cleanup be documented?
  - what are some of the factors that limit the effectiveness of cleanup techniques?

- Subsurface Oil - residual oil trapped in beach sediments within the intertidal zone.
  - is subsurface oil a significant source of re-oiling?
  - does subsurface oil pose a significant contaminant source to nearshore biota?
  - is it worthwhile and beneficial to clean it up? If so, how?

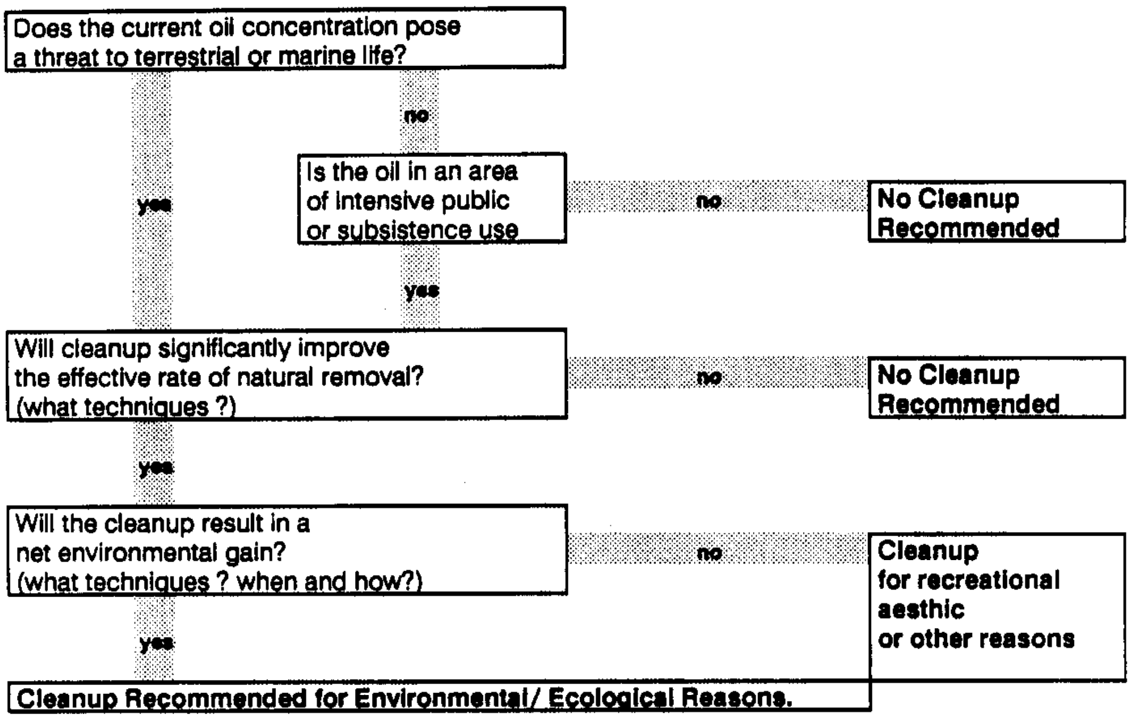
- Bioremediation - enhancement of natural biodegradation of stranded oil by introduction of fertilizers or non-native, biodegrading organisms.
  - how effective is bioremediation?
  - what is the impact of bioremediation?
  - what of is the role of bioremediation in future response operations?

Hypotheses to evaluate these issues and questions are outlined within the preliminary experimental design.

APPLICATION OF FINDINGS

By addressing the issues described, the results from the experiments will expedite the decision-making process at future spills . It will provide a basis to answer questions commonly asked during cleanup operations, and contained in decision trees.

EXAMPLE OF AN ABBREVIATED SHORELINE CLEANUP DECISION TREE



It can be expected that the experiment will generate sound data and scientific evidence upon which response personnel can base decisions as to the correct choice of cleanup options; to provide guidance in the selection of environmentally acceptable cleanup techniques of known effectiveness.....those which maximize the rate of cleanup while minimizing the environmental damage associated with the cleaning technique itself. The net environmental gain due to the use of particular cleanup techniques will be more evident. The relative impact of applying a cleaning technique versus the impact of not using it will be defined. The impact or net environmental gain will be demonstrated in terms of degree of impact and acceleration of natural recovery.

PRELIMINARY EXPERIMENTAL DESIGN

OILSPILL SCENARIO

Previous reports on shipping along the Pacific coast identify crude oil as the most common oil in terms of volume, and bunker oils as the most common oil in terms of frequency of transport (Cohen and Aylesworth 1990; Dickins 1990). Available risk analysis (Dickins et al., 1990) shows that bunker spills will be more frequent but relatively small (1,000s of bbl), and that crude oil spills are likely to be less frequent, but large (10s to 100s thousands of bbl). Both oil types are of concern and need to be considered for testing in experimental spills.

A large proportion of spills originate from either a grounding or vessel collision in restricted waters near the coast where only moderate weathering would occur before the oil reaches the shore. In these incidents, the oil loading of beach sediments is assumed to be high due to close proximity of the spill source (heavy shoreline oiling can be expected in hours to days). A saturation loading of beach sediments could in fact occur.

Likely scenarios for spills in high risk navigation areas suggest that the experimental design consider two basic oil types, the crude oil that might originate from a tanker spill and bunker oil that might originate from a cargo vessel or barge spill. The oil needs to be artificially weathered to simulate "a few days" weathering prior to stranding on a beach. The option exists for using either emulsified or non-emulsified oil. A relatively 'heavy' oil loading of experimental plots is required to simulate large quantities of stranded oil (several cm). Sufficient oil must be deposited to provide a rigorous realistic test.

SHORELINE TYPE

The coastal category referred to as mixed sediment beach was selected as the primary shoreline type. These are normally comprised of poorly sorted mix of boulder, cobble, pebble, granule and sand. Another beach type of concern is a somewhat better sorted pebble/cobble mix or coarse sediment beach.

Mixed and coarse sediment shorelines are present along about 10-15% of the British Columbia coast (bedrock shore comprises most of the remainder). In areas of low to moderate wave energy, the shallow subtidal and intertidal zone is biological productive.

Experience from recent spills has demonstrated that permeable, coarse or mixed sediment beaches are effective traps for oil, and that oil residence under some circumstances is likely to be lengthy. Although surface oil may be removed from the beach by wave action, subsurface oil remains trapped where wave action cannot easily disperse the oil. This subsurface oil is a source for re-oiling (or oiled or clean areas) and as a contaminant source to nearshore biota and resources. Beaches which experience subsurface oiling have proved to be very difficult to clean. Coarse and mixed sediment beaches were of principal concern in terms of cleanup operations at both 'Nestucca' and 'Exxon Valdez'.

The ideal experimental site will include permeable coarse or mixed sediment beaches with particle sizes ranging from sand to cobble. High permeability would be the primary prerequisite, and may be assumed with sand contents of less than 5-10%. This would preclude most of the areas of very low wave energy. High wave energy beaches with strong self cleaning action would not be suitable. Shorelines with moderate to low-mod wave exposure would be the most likely candidates.

SHORELINE CLEANUP TECHNIQUES (FOR ASSESSMENT)

Shoreline cleanup crews typically approach cleanup with an array of cleanup techniques (see Appendix B for a partial listing). The final "suite" of techniques used in a response will vary significantly depending on the logistics, oil type and volume, nature of the shoreline etc.

The primary techniques for evaluation were selected by shoreline cleanup experts. Basically, these are previously used, common techniques about which quantitative information is lacking. They are techniques most likely to be considered in future spill response plans. They are techniques about which controversial decisions must be made.

Flooding and Washing: The flooding technique consists of pumping large quantities of sea water onto the upper part of the beach to raise the ground water table; the washing technique consists of washing free oil off the beach face onto the water surface where it is collected within booms. This flood and wash combination is effective in removing large quantities of free oil from the surface and immediate subsurface. Two variations are recommended for testing: the cold water, low pressure variant (minimal ecological (intertidal) impact and wide use in past spills, and the hot water, high pressure variant (generally considered more efficient at removing oil, especially 'older' weathered oil, but with greater ecological impact).

Tilling: This technique is used for treating subsurface oil after surface oil has been removed by either washing or natural weathering. The beach is tilled or mixed to bring subsurface oil to the beach surface where wave action, weathering and biodegradation are more effective in removing the oil. The technique is one of the most disruptive of the mechanical treatment techniques. Many of the biota are destroyed as the substrate is churned and turned over.

Beach cleaning agents: This involves the use of additives to the washing systems, to enhance removal of oil during washing (eg like using dishsoap). Another variation is to apply the beach cleaner before the washing ie to provide a 'soak' stage. Using beach cleaners is a variation of the washing technique, the primary shoreline cleanup technique for large spills, and has the potential to increase effectiveness of the technique. There is, however, concern that the additives may have a significant negative impact on biota, or relocate free oil into the water column and thus reduce its recovery and/or effect biota there.

Bioremediation: Increases the biodegradation of oil by (a) the addition to nutrients to increase the population of indigenous bacteria or (b) the addition of non-native, oil-degrading bacteria. Bioremediation is routinely used as a polishing technique and as a treatment for deposits of low-concentration residual oil. Nevertheless, its use is controversial, the effectiveness and biological impact are poorly understood. To help define the role of bioremediation in future spill response, a full scale field trial is recommended. Careful consideration of analytical techniques will be required.

Other techniques were considered for evaluation but were judged to be of lower priority. These included: in situ burning, "clay" scavenging, water injection or "lancing", excavation and removal, rock washing, incinerators, sorbents, etc. These were considered potentially useful techniques, but their assessment was considered less critical than the primary techniques selected because generally they are used on a smaller scale, and because the number of techniques had to be limited to restrict the size of the experiment.

Excavation followed by removal/replacement or incineration/replacement or rockwashing/replacement are all techniques which are highly disruptive to intertidal substrate. It was judged that tilling, which also disrupts intertidal substrate, would provide some insight into the possible impacts of these techniques.

EXPERIMENTAL SET-UP

The variables of two oil types and five cleanup techniques or treatments, place an upper limit of ten possible primary individual experiments.

The number of individual oil releases (oiled sites) will depend on the number of individual experiments that are actually carried out. The size of each oil release will depend on several variables. These include the length of shoreline required for a meaningful test, the intertidal width, the desired oil loading, the nature of the cleanup techniques being tested, and the porosity of the sediment. The latter will be one of the more important factors.

The conceptual design calls for the use of four separate beach segments or small embayments for each experiment. These are;

OT	oiled	+ treatment (technological cleanup)
OC	oiled	+ no treatment (natural cleanup) -Control site
T	unoiled	+ treatment
C	unoiled	+ no treatment *-Control site*

Each of the four sites would be one of two sizes,
-either a bay with shoreline lengths estimated ≥100m or more,
-or a pocket beach with shoreline lengths estimated ≥50m.
Intertidal widths of 15m or more could be expected.
Control sites would be shared ie. the same sites between experiments.

The basic set-up for testing each cleanup technique is described below for crude oil and bunker. These are schematically indicated in Figure 1 and 2 respectively. The associated hypothesis and priorities of each experiment are subsequently discussed.

Experiment #1

CRUDE OIL - Flooding/Cold-water, Low Pressure Washing

Two bays are oiled, one of which is subject to cold-water, low pressure washing (Site OT1); the other bay is an oiled untreated control (Site OC). An unoiled bay is subject to washing (Site T1) and another bay is established as a control (Site C).

Intensive monitoring of intertidal populations of invertebrates and macroflora would be conducted in all bays. Selective effects to nearshore subtidal benthos would be monitored in Bays OT1, OC (and C). Indicator species may be used, including those of ecological or commercial importance. Oil budget monitoring would be conducted at a level consistent with the accuracy or existing methodology. Emphasis would be placed on the period when oil concentrations are high and on the use of non-chemical analytical procedures. Limited total hydrocarbon (TH) and GC/MS analysis would be conducted on sediment, water and tissue samples.

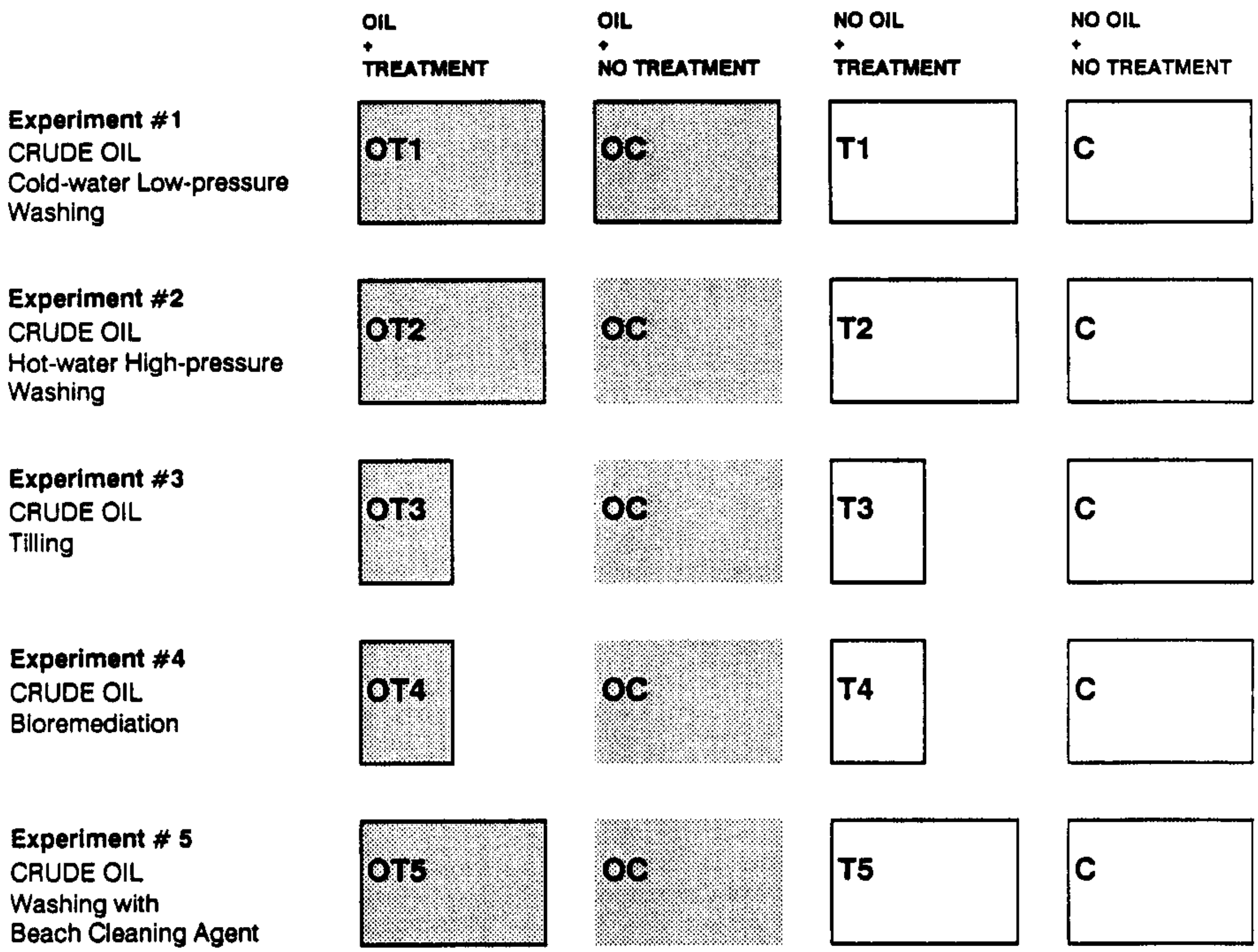
Experiment #2

CRUDE OIL - Flooding/Hot-water, High Pressure Washing

Two bays are oiled, one of which is subject to hot-water, high pressure washing (Site OT2); the other bay is an untreated control (Site OC). An unoiled bay is subject to washing (Site T2) and another bay is established as a control (Site C).

Intensive monitoring of intertidal populations of invertebrates and macroflora would be conducted in all bays. Selective effects to nearshore subtidal benthos would be monitored in Bays OT2, OC (and C). Indicator species may be used, including those of ecological or commercial importance. Oil budget monitoring would be conducted at a level consistent with the accuracy or existing methodology. Emphasis would be placed on the period when oil concentrations are high and on the use of non-chemical analytical procedures. Limited total hydrocarbon (TH) and GC/MS analysis would be conducted on sediment, water and tissue samples.

FIGURE 1. EXPERIMENTAL SET-UP FOR CRUDE OIL



Note: Full box indicates a `bay' sized experimental site; half box indicates a beach sized experimental site.

Experiment #3

CRUDE OIL - Beach Tilling

Two bays are oiled, one of which is subject to tilling after surface oil has been removed, possibly by washing (Site OT3); the other bay is an untreated control (Site OC). An unoiled bay is tilled (Site T3) and another bay is established as a control (Site C).

Intensive monitoring of intertidal populations of invertebrates and macroflora would be conducted in all bays. Nearshore subtidal populations would *not* be monitored, however, effects to indicator species may be tested, including those of ecological or commercial importance. Oil budget monitoring would be conducted at a level consistent with the accuracy or existing methodology. Emphasis would be placed on the period when oil concentrations are high and on the use of non-chemical analytical procedures. Limited total hydrocarbon (TH) and GC/MS analysis would be conducted on sediment, water and tissue samples.

Experiment #4

CRUDE OIL - Bioremediation

Two pocket beaches are oiled, one of which is subject to bioremediation (Site OT4); the other bay is an untreated control (Site OC). An unoiled bay is subject to bioremediation (Site T4) and another bay is established as a control (Site C).

Intensive monitoring of intertidal populations of invertebrates and macroflora would be conducted in all bays. Nearshore subtidal populations would *not* be monitored unless there were predictions of growth enhancement induced by the fertilizers. Effects to indicator species may be tested. Oil budget monitoring would be conducted at a level consistent with the accuracy or existing methodology. Emphasis would be placed on the period when oil concentrations are high and on the use of non-chemical analytical procedures. Limited total hydrocarbon (TH) and GC/MS analysis would be conducted on sediment, water and tissue samples. Other specialized analysis to measure the occurrence and rate of biodegradation processes would be undertaken.

Experiment #5

CRUDE OIL - Cold-water, Low Pressure Washing with Cleaning Agents

Two bays are oiled, one of which is subject to cold-water, low pressure washing using additives or beach cleaning agents (Site OT5); the other bay is an untreated control (Site OC). An unoiled bay is subject to washing (Site T5) and another bay is established as a control (Site C).

Intensive monitoring of intertidal populations of invertebrates and macroflora would be conducted in all bays. Selective effects to nearshore subtidal benthos would be monitored in Bays OT5, T5, OC (and C). Indicator species may be used, including those of ecological or commercial importance. Oil budget monitoring would be conducted at a level consistent with the accuracy or existing methodology. Emphasis would be placed on the period when oil concentrations are high and on the use of non-chemical analytical procedures. Limited total hydrocarbon (TH) and GC/MS analysis would be conducted on sediment, water and tissue samples.

Experiments #6-#10

BUNKER OIL - All techniques

The experimental set-up for the use of Bunker oil would be similar to that proposed for the crude oil experiments. It is conceptually illustrated in Figure 2.

In order to limit the size of the experiment, the biological effects of Bunker would only be monitored in the intertidal zone. As such, the overall size of the experiments is less than that required for the crude oil. That is not to dismiss potential Bunker effects in the nearshore subtidal environment, or the fact that it may be more persistent. Bunker is generally assumed to be less toxic and less mobile than crude oil, therefore it may be possible to extrapolate short-term subtidal effects monitored from crude oil.

FIGURE 2. EXPERIMENTAL SET-UP FOR BUNKER FUEL

	OIL + TREATMENT	OIL + NO TREATMENT	NO OIL + TREATMENT	NO OIL + NO TREATMENT
Experiment #6 BUNKER Cold-water Low-pressure Washing	BT1	BC	T1	C
Experiment #7 BUNKER Hot-water High-pressure Washing	BT2	BC	T2	C
Experiment #8 BUNKER Tilling	BT3	BC	T3	C
Experiment #9 BUNKER Bioremediation	BT4	BC	T4	C
Experiment # 10 BUNKER Washing with Beach Cleaning Agent	BT5	BC	T5	C

These are the same sites as used in the Crude Oil Experiments (Fig 1)

Note: Full box indicates a `bay' sized experimental site; half box indicates a `beach' sized experimental site.

HYPOTHESES AND IMPLICATIONS

The major hypotheses being tested within each individual experiment crude oil experiment are the are the same. They are described below by comparing each paired combination of the four test sites utilized in each individual experiment. In reality these will also be further combined into a more complex comparison/hypothesis.

It should be noted that some hypotheses could be true over the short-term but false over the long-term. Since these temporal differences will have important implications to decision making, monitoring must extend long enough to accommodate the collection of necessary data.

It should also be noted that some hypotheses could be true for the intertidal but false for the subtidal, or visa versa. Both separate and integrated conclusions must be drawn.

Hypotheses and implications from the Bunker experiments would all follow the same rationale as for the crude oil experiments, so are not repeated.

1a Compare Biological Data between Sites OT_X and OC (where x= 1-5)

Treatment of an oiled beach results in significantly less impact on intertidal (and/or nearshore[1]) biota than not treating an oiled beach. **Total impact of the oil and cleaning operations > impact of the oil left to natural recovery.**

If true, then there is a good environmental justification for the treatment of beaches (using the cleanup technique being tested).

1b Compare Oil Budgets between Site OT_X and OC (where x= 1-5)

Treatment significantly reduces the amount of oil in a beach in comparison to no treatment. **Quantity of oil removed by the cleaning operation > quantity of oil removed by natural recovery.**

If true, then the treatment (being tested) would be considered an effective oil removal technique. A estimate of the quantity over time would demonstrate when natural removal rates equalled technological cleanup.

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[1]Applies to experiment #1, #2, and #5.

2 Compare Biological Data between Sites OT_X and T_X (where x = 1-5)

Treatment of an oiled beach results in significantly less impact on the intertidal biota (and/or nearshore[2]) than treatment of an unoiled beach. **Total impact of the oil and cleaning operations > impact of the cleaning operations itself.**

If true, it means even though the treatment (being tested) may in itself be disruptive and cause impact to intertidal biota, there is still a net environmental gain to removing the oil with this cleanup technique. If false, then hypothesis 1 must be carefully evaluated.

3 Compare Biological Data between Sites OT_X and C (where x = 1-5)

Treatment of an oiled beach significantly impacts the intertidal (and/or nearshore[1]) biological community. **Collectively, the oil and cleaning operations have an impact.**

If true, then there may be environmental justification for cleanup; the implication if the hypothesis is rejected is that treatment (using the treatment being tested) must be justified for aesthetic reasons.

4 Compare Biological Data between Sites OC and T_X (where x = 1-5)

Leaving oil on a beach (no treatment) results in more impact than treatment of an unoiled beach. **Impact of the oil left to natural recovery > the impact of the cleaning operation by itself.**

If true, the implication is that even though the treatment (being tested) may cause an impact on biota, there is a net environmental gain due to removal of the oil; however, if false, then hypothesis 1 should be carefully evaluated.

5 Compare Biological Data between Sites OC and C

Leaving oil on a beach (no treatment) results in a significant impact on the intertidal and nearshore biological community. **The oil left to natural recovery has an impact.**

If true, there is justification for treatment; however, if over the long-term it proves false, then there may be no compelling ecological justification for cleanup.

6 Compare Biological Data between Sites T_X and C (where x = 1-5)

Treatment of an unoiled beach results in a significant impact on the intertidal biological community. **The cleaning operation by itself has an impact.**

If true, it indicates that the cleanup technique itself causes significant impact and hypothesis 2 must be carefully evaluated.

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[2]Applies to Experiment #5

There are several additional hypotheses that can be developed from intercomparison of the individual data sets and that address the principal objective of the project.

7 Compare Biological Data Among Sites, OT1, OT2, OT3, OT4, OT5
Determine comparative relative impact of different cleanup techniques, eg OT3 > OT2 > OT1.

8 Compare Oil Budget Data Among Sites, OT1, OT2, OT3, OT4, OT5
Determine comparative relative impact of different cleanup techniques.

The intercomparison of results from the different experiments adds another dimension of benefits which can be derived from the results. It provides primary criteria that can be built into decision-making tree. Not only can the tradeoff between environmental damage due to the countermeasure be evaluated against increases in benefits from removal of oil. Moreover it will demonstrate which countermeasures cause greater environmental damage and remove less oil than other countermeasures for the oil spill scenario being tested.

It should be noted that the extent to which intercomparison of techniques can reliably proceed, will be influenced by the similarity of test sites.

EXPERIMENTAL PRIORITIES

Limited resources, funding constraints, available sites, or permits provisions may prevent the full suite of experiments from proceeding within a single program. The following guidelines are recommended to assist in assigning experimental priorities.

- Crude Oil Experiments in preference to Bunker Oil Experiments
  Crude oil on shorelines is generally more difficult to clean up because low viscosity allows significant penetration into beaches; crude oil is more toxic than bunker.

- Flushing and Tilling in preference to Bioremediation/Cleaning Agents
  Experiments Flushing is a first response technique that is widely used during accidental spills; Tilling is representative of other mechanical excavation

techniques that are used on coarse sediment beaches, but less used than flushing; Bioremediation is frequently used but probably removes only a small proportion of oil compared to natural weathering; Cleaning agents have not been widely used, but are strongly promoted at spills.

- A Few, Well-Documented Tests in preference to Many, Poorly Documented Tests
  Field experiments are so rare in the field of spill response research that it is important to document them extremely carefully. Field results are often cited as critical evidence in decision-making or in numerical modelling of spill behaviour in real spill situations.

Based on these guidelines, the experimental priorities from highest to lowest are;

1. CRUDE OIL - Flooding/Cold-water, Low Pressure Washing
2. CRUDE OIL - Flooding/Hot-water, High Pressure Washing
3. CRUDE OIL - Beach Tilling
4. CRUDE OIL - Bioremediation
5. CRUDE OIL - Low Pressure Washing with Cleaning Agents
6. BUNKER - Flooding/Cold-water, Low Pressure Washing
7. BUNKER - Flooding/Hot-water, High Pressure Washing
8. BUNKER - Beach Tilling
9. BUNKER - Bioremediation
10. BUNKER - Low Pressure Washing with Cleaning Agents

SECONDARY STUDIES

In addition to the primary experiments described, a variety of subsidiary and supportive studies could be conducted which would take advantage of the infrastructure and experimental conditions. These could include biological studies to further identify and quantify the effects of oil on important biological processes and functional relationships; or studies to evaluate new monitoring techniques; or to evaluate other promising cleanup techniques on a small scale.

Secondary studies would not entail additional oil releases.

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APPENDIX B PARTIAL LIST OF SHORELINE CLEANUP TECHNIQUES

Deluge or Flooding
Cold-water, Low-pressure Washing
Hot-water, High-pressure Washing
Steam Cleaning
Water Injection or Lancing

Relocation of Sediments for Natural Cleaning
Tilling
Excavation and Removal
Rock-washing

Raking
Manual Pick-up
Wiping, Brushing

Bioremediation

Cleaning Agents
Solidifiers
Wetting Agents
Sinking Agents
Dispersants

In situ burning
Incinerators

Sorbents
Clay "scavenging"
Geotextiles

AND COMBINATIONS OF THE ABOVE